TMDL Endpoint for Contaminated Sediment Impairments Due to Metals

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Outline

- Review of 1998 Listings
  - Why?
  - Where?
  - How Much
- Verified with respect to 2002 Listing Methodology
- Introduction of TMDL Endpoint – MERM-Q basis
- Rationale for TMDL Endpoint

Review of 1998 Listings

Impaired Segment	Impairing Toxic Substances	Lines of Evidence For Decision	Data Used
Bear Creek (to mouth)	Cr, Zn, PCBs	Sediment Chemistry, Amphipod Toxicity Benthic Community Impaired	Hall 1994 (Support) Baker, 1996 McGee & Fisher, 1996, 1997
Curtis Creek (to mouth)	Zn, PCBs	Sediment Chemistry, Amphipod Toxicity Benthic Community Impaired	Hall 1994 (Support) Baker, 1996 McGee & Fisher, 1996, 1997
Middle Harbor (mainstem from Outer Harbor to Inner Branches)	Zn	Sediment Chemistry, Amphipod Toxicity Benthic Community Impaired	Hall 1994 (Support) Baker, 1996 McGee & Fisher, 1996, 1997
Northwest Harbor (to boundary of Middle Harbor)	Cr, Pb, Zn, PCBs	Sediment Chemistry, Amphipod Toxicity Benthic Community Impaired	Hall 1994 (Support) Baker, 1996 McGee & Fisher, 1996, 1997

Basis For 303(d) Listing

- Sediment Quality Triad
- Three Data Components
- Weight of Evidence Approach
  - Benthic Community Analysis
  - Bulk Sediment Toxicity
  - Bulk Sediment Chemistry
- Minimizes Need for “BPJ”

Sediment Toxicity:

- Direct relevance to Water Quality Standards
- COMAR 26.08.02.03:
  - B. General Water Quality Criteria. The waters of this State may not be polluted by:
    - (5) Toxic substances attributable to sewage, industrial wastes, or other wastes in concentrations outside designated mixing zones which:
      - (a) Interfere directly or indirectly with designated uses, or
      - (b) Are harmful to human plant or aquatic life

- Degradation of the benthic community due to sediment contamination directly interferes with designated uses through toxicity to aquatic life.
- Greatest weight given to toxicity tests of the 3 data components when making impairment decision.

Benthic Community Assessment

- Benthic Assessment is an important tool because:
  - More rigorous method than chemistry or toxicity testing that may be dependent on uncontrollable variables.
  - Measures a holistic community response to water quality rather than subjective endpoints.
  - Integrates responses through time and cumulative impacts.

- Limitations: Benthic assessment cannot be used as a "stand alone" tool (especially in the Harbor) for determination of sediment quality as it may be influenced by a number of non-contaminant impacts (D.O. habitat alteration, etc).

Bulk Sediment Chemistry

- 2002 303(d) Listing Methodology.
  - 1 or more contaminants > 2X ERM
  - MERMQ ≥ 0.5 **
  - 5 or more contaminants > ERM
  - Sediment Chemistry exceeded the EPA ESG (Equilibrium Partitioning-Based Sediment Guideline)

  - ** MERMQ = Mean ERM Quotient

TMDL ANALYSIS 101

TMDL Analysis Basics

SOURCE:

- Load/Stressor
- Threshold for Impairment = TMDL

RECEPTOR (waterbody)

- Water Quality Response
- Water Quality Criterion = the WQ Endpoint

Note QUANTIFIED Endpoints on both sides: TMDL & WQ Endpoint

TMDL WQ Endpoint Basics

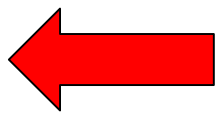
303(d) Listing Endpoint

- Used to determine Impairment
- Uses Observed Data

TMDL Analysis Endpoint

- Used to Determine TMDL, consistent with 303(d) Listing.
- Uses Modeling Output

Recall 303(d) Listing for Toxic Substances

- Fish Tissue **Not Present Concern**
- Water Column Concentration **Not Present Concern**
- Sediment Triad:
  - Benthic Community **Not Readily Modeled**
  - Sediment Toxicity Test **Not Readily Modeled**
  - Sediment Chemistry  **FOCUS HERE**

Focus on Sediment Chemistry for TMDL Endpoint

Sediment Chemistry 303(d) Considerations:

1. Sediment chemistry data exceeded the EPA ESG, or
2. Sediment chemistry data exceeded the ERM's, or other screening values, by a factor of two, or
3. The Mean ERM Quotient is greater than 0.5, or
4. Sediment chemistry data exeeded more than 5 ERMs

Source: Maryland 303(d) Listing Methodology

Focus on Sediment Chemistry for TMDL Endpoint (Con't)

Two Thresholds to be Considered:

1. Mean ERM Quotient of 0.5
   - Set a Threshold on the Average Concentration for a given Waterbody Segment.

2. Concentration of two-times the ERM
   - Set a Threshold on the Maximum Concentration within a given Waterbody Segment.

The Mean ERM Quotient

The MERM-Q What is it?

- MERM-Q = Mean ERM Quotient
- An Sediment Quality Guideline (SQG) –based tool for assessing the toxicity potential of complex mixtures in contaminated sediment by relating a sediment concentrations to possible/probable? toxic outcomes.
- Utilizes the ERM = Effects Range Median – empirically derived sediment quality guideline (SQG) based on co-occurrence of toxicity at a certain chemical concentration threshold.
- The ERM is the median effects range – effects are likely to occur.
- ERM is an SQG for use in marine and estuarine sediments
  - Example ERM for Chromium = 370 mg/kg D.W.

MERM-Q Cont'd

- MERM-Q = Σ ($\frac{\text{[Chemical x]}}{ERM_X}$) / # Stations
- Example: Zn in Bear Creek (ERMs is in parentheses)
  - Zn (410) = 2105, 2574, 1762, 1791, 2057, 1720, 1507, 1664, 1786, 2175

$$\text{MERM-Q} = \sum \left(\frac{2105}{410} + \frac{2574}{410} + \frac{1762}{410} + \frac{1791}{410} + \frac{2057}{410} + \frac{1720}{410} + \frac{1507}{410} + \frac{1664}{410} + \frac{1786}{410} + \frac{2175}{410}\right) / 10$$

$$= \frac{5.13 + 6.27 + 4.29 + 4.36 + 5.01 + 4.19 + 3.67 + 4.05 + 4.35 + 5.30}{10}$$

$$= 4.662$$

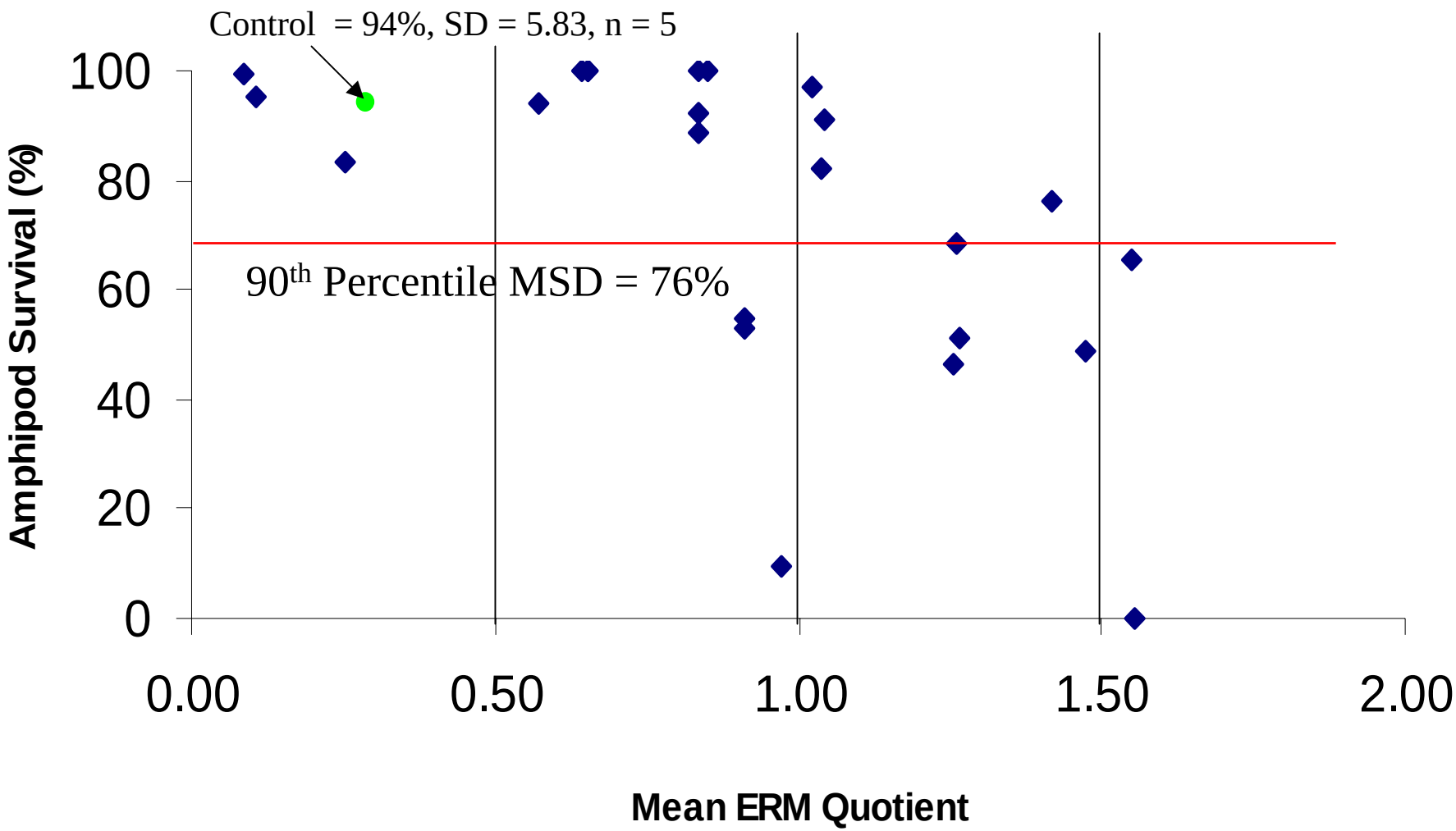
MERM-Q: Correlation with Amphipod Toxicity

- Results (Based on 1513 matched sediment – toxicity test pairs - Long et.al. 2000)

	MERM-Q	Probability Tox.
– MERM-Q =	0.11 – 0.5	21 %
– MERM-Q =	0.51 – 1.5	49 %
– MERM-Q =	> 1.5	76 %

Toxic = Sig. Lower ($p < 0.05$) than controls and < 80% of mean survival of controls. (Detectable Significance Value – Thursby et.al. 1997)

1. MERMQ VS Amphipod Survival



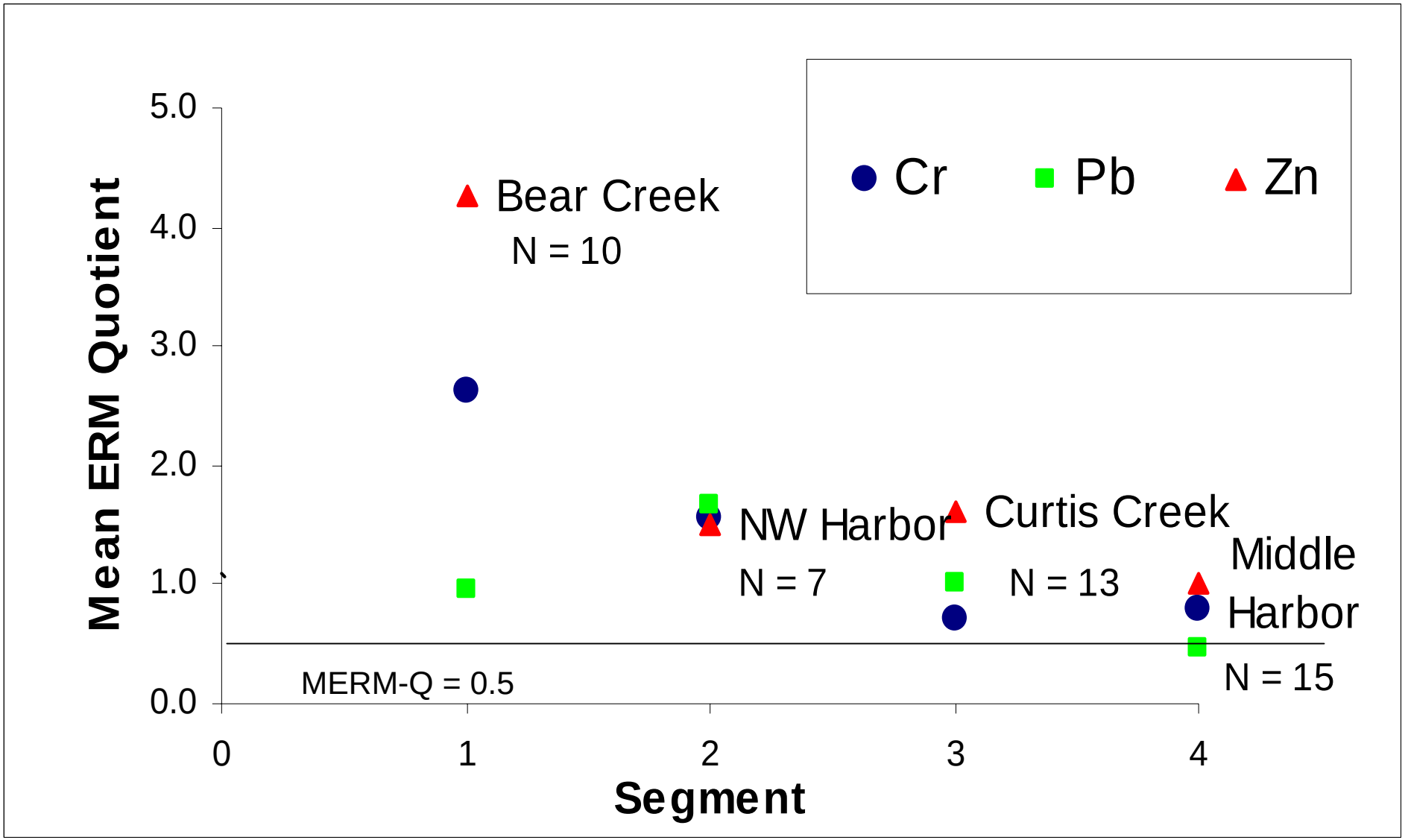
Mean ERM Quotient: Assumptions

- Toxicological mechanisms of the contaminants are additive.
- ERM Quotient approach is meant to serve as a central tendency indicator (i.e. as means of multiple individual quotients) of contamination for a complex sediment matrix.
- Potential impact from any one component is minimized.
- Potential for toxicity increases as magnitude of contaminant concentration increases.
  - Ex. Zn (ERM = 410) p (Tox) = 2500 > 1000 > 750 > 440

TMDL Target Recommendations

- Set targets for metals of concern based on achievement of a Mean ERM Quotient of 0.5 or less in the sediment.
  - Cr (ERM = 370) Target = 185 mg/kg D.W.
  - Pb (ERM = 218) Target = 114 mg/kg D.W.
  - Zn (ERM = 410) Target = 205 mg/kg D.W.
- Attainment of water quality standards may be assessed by:
  - Sediment concentrations attaining the proposed target levels, **or**
  - An maximum acceptable sediment effect level for toxicity (minimal acute and/or chronic toxic impacts)
  - This level is under discussion within the Department

2. Spatial MERM-Q For Metals in Impaired Baltimore Harbor Segments



Summary

- 303(d) Listing is based on Sediment Quality Triad (Weight of Evidence) – Chemistry, Toxicity, Benthic Biology
- The MERM-Quotient is a tool that enables a prediction of the probability of toxicity to a chemical mixture in sediment.
- This method assumes contaminant additivity in the mixture.
- Each component is assessed as quantified independently.
- The Department is proposing the Mean ERM-Quotient as a TMDL WQ target for metals in Baltimore Harbor sediments.
- The Harbor TMDL process is iterative in nature – TMDL will be re-evaluated every 5 years and endpoints/implementation may be modified based on preponderance of new data and or methods.

QUESTIONS ????

Change From “ER-40”

- The “ER40” (Effects Range Median (ERM) – 10% Safety Factor) was a preliminary attempt at defining contaminant concentration targets for the Harbors’ TMDLs pertaining to sediment toxics.
- Rationale: “ER40” chemical concentrations were similar to sediment criteria developed for FL and WA
- No reasonable assurance that WQS (absence of toxicity to aquatic organisms) will be attained.
- Solution: use Mean ERM Quotients (MERM-Q) as a tool to examine the probability of toxicity in a sediment given a set of contaminants.